

**Telephone communication system and method
over local area network wiring**

FIELD OF THE INVENTION

The present invention relates to the field of common networks for data communication and telephony, and, more specifically, to the networking of telephone sets within a building over digitally oriented local area network wiring, simultaneously with the data transmission.

BACKGROUND OF THE INVENTION

Small office and business environments commonly employ a multiplicity of work cells, each equipped with a telephone set and a computer. Two separate networks are usually employed for communication among the cells and between them and the outside world - a telephone network, connecting between the telephone sets and outside telephone lines, and a so-called local area network (LAN), connecting the computers among themselves and to outside network lines.

The term computer or personal computer will be understood to include a workstation or other data terminal equipment (DTE) or at least one digital device capable of inputting and outputting data, whereby each computer includes an interface for connection to a local area network (LAN), used for digital data transmission; any such device will also be referred to as a remote digital device. The term telephone set will be understood to include any device which can connect to a PSTN (Public Switched Telephone Network), using telephony band signals, such as fax machine, automatic answering machine or dial-up modem; any such device will also be referred to as a remote- or local telephone device.

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Another, opposite approach is to utilize an existing telephone infrastructure for simultaneously serving as both telephone and data networking. In this way, the task of establishing a new local area network in a

home or other building is simplified, because there are no additional wires to install.

U.S. Patent 4,766,402 to Crane teaches a way to form a LAN over two-wire telephone lines, but without the telephone service.

5 The concept of frequency division multiplexing (FDM) is well-known in the art, and provides a means of splitting the inherent bandwidth of a wire into a low-frequency band, capable of carrying an analog telephony signal, and a high-frequency band, capable of carrying data or other signals. Such a technique, sometimes referred to as 'data over voice', is described, for
10 example, in U.S. Patents 5,896,443, 4,807,225, 5,960,066, 4,672,605, 5,930,340, 5,025,443 and 4,924,492. It is also widely used in xDSL systems, primarily Asymmetric Digital Subscriber Loop (ADSL) systems.

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15 A typical system employing FDM is illustrated in Fig. 2, which shows schematically a combined telephony/data network **20**, providing in this case connections to two work cells by means of corresponding two cables **12a** and **12b**, each comprising a single twisted pair of wires. The lower part of the spectrum of cable **12a** is isolated by Low Pass Filters (LPF) **22a** and **22b**, each connected to a respective end of the cable. Similarly, the higher part of the spectrum is isolated by respective High Pass Filters (HPF) **21a** and **21b**. The
20 telephony network uses the lower spectrum part by connecting the telephone **13a** and the PABX **11** to the respective LPFs. In order to use the higher part of the spectrum for data communication, telephone-line modems **23a** and **23b** are respectively connected to the HPFs **21a** and **21b** at both cable ends. Hub **16** connects to modem **23a**, while, on the user side, modem **23b** connects to
25 computer **18a**, thus offering connectivity between the computer and the hub. The spectrum of the other cable **12b** is similarly split and cable **12b** connects telephone set **13b** to PABX **11** via LPFs **22c** and **22d**, while computer **18b** connects to hub **16** via modem **23d**, coupled to HPF **21d**, and modem **23c**, coupled to HPF **21c**. Additional telephones **13** and computers **18** can be added

in the same manner. This prior-art concept is disclosed in U.S. Patent 4,785,448 to Reichert *et al.* (hereinafter referred to as "Reichert") and U.S. Patent 5,841,841 to Dodds *et al.* (hereinafter referred to as "Dodds"). Both Reichert and Dodds suggest a method and apparatus for applying frequency
5 domain/division multiplexing (FDM) technique for residential telephone wiring, enabling simultaneously carrying telephone and data communication signals, as described above.

Network 20, employing an FDM method, typically requires two modems (such as 23a and 23b in Fig. 2) for each connected cell. Such modems
10 are complex and expensive. In addition, the low communication quality of a typical telephone line, which was designed to carry low-frequency (telephony) signals only, limits both the data-rate and the distance of the data communication.

The concept of forming a phantom channel to serve as an additional path
15 in a two wire-pairs communication system is known in the art of telephony, and disclosed in several patents, classified under U.S. Class 370/200. Commonly, such a phantom channel path is used to carry power to feed remote equipment or intermediate repeaters. In some prior-art systems, exemplified by U.S. Patents 4,173,714, 3,975,594, 3,806,814, 6,026,078 and 4,937,811, the
20 phantom channel is used to carry additional signals, such as metering and other auxiliary signals. Thus, all such systems use the phantom channel only as means for helping the communication service over the main channels. None of the mentioned prior-art uses the phantom channel for carrying an additional communication type of service, or for functionally combining two distinct
25 networks.

It would thus be desirable to allow a data networking system to simultaneously also provide telephone service without any additional wiring.

SUMMARY OF THE INVENTION

It is an object of the invention to allow a data networking system to simultaneously also provide telephone service without any additional wiring.

This object is realized in accordance with a broad aspect of the invention
5 by a communication network for providing simultaneous digital data- and analog telephone communication between a central location and at least one remote location, the communication network comprising:

a central digital device,

a central telephone device and,

10 for each remote location – a remote digital device, a remote telephone device and a cable having a remote end at the respective remote location and a near end at the central location;

said cable including at least two pairs of conductors, each pair operative as a data channel for carrying data signals between said remote digital device
15 and said central digital device and said at least two pairs cooperatively forming a phantom channel, operative to carry telephone signals between said remote telephone device and said central telephone device.

Conventional data networks use a four-conductor circuit arrangement providing two communication channels between two units. For example, in a
20 local area network based on Ethernet 10BaseT or 100BaseTX, two pairs of conductors are employed between a hub and DTE such as a computer. By means of the invention, POTS connection, such as between exchange and telephone apparatus, is accomplished simultaneously over the same four conductors used for the two communication channels without interference. The
25 POTS service communication is accomplished via a phantom circuit arrangement over the four conductors.

Such configuration can be employed within small office or small business, wherein single wiring infrastructure is used for distributing both data and telephone signals from a central location, including a hub and an exchange

to a remote station, each such station comprising a telephone unit and a data unit (e.g. desktop computer).

The present invention also provides a circuit arrangement wherein a cable that includes two twisted-conductor pairs provides both a two-way data communication channel for a connected computer and, simultaneously, a path for POTS signal to and from a connected telephone set, using the phantom channel method. In the preferred embodiment, the data communication channel consists of an Ethernet IEEE802.3 LAN channel and 10BaseT, or 100BaseTX, interfaces.

According to the invention, each two-conductor pair is terminated at each of its ends with a center tapped primary transformer winding (hereinafter cable-side winding), whereby each conductor of the pair is connected to a respective end of the cable side winding. Each winding is inductively coupled to a secondary winding (hereinafter referred to as equipment side winding), whose ends are connected to another pair of conductors that form the continuation channel for the data carrying signal, wherein the equipment side winding is connected to the data communication equipment. The center taps of each of the two primary winding at any end of the cable are connectable to the respective conductors of a telephone circuit, to carry the POTS signals. Thus, the two pairs of conductors at opposite ends of the cable, through the center taps of the respective primary transformer windings, form first and second connections of the two conductor phantom channel, which is used for carrying the telephone signal.

The invention can be implemented by means of two modules - one at each end of the two-conductor-pairs cable. Each module comprises two transformers, with a center-tap in the primary (cable side) winding. The module retains the two-pair data communication capability, while simultaneously including a phantom channel via the center-tap connections, for telephone service. The phantom channel can be accessed via a connector in the module.

The module can be a stand-alone unit, or integrated within any unit in the network, such as a digital network hub, a telephone exchange, a server computer or telephone set. Alternatively, the module can be integrated within a wall outlet connected to one or both ends of the cable.

5 In another embodiment, the modules form a kit, which is used to upgrade an existing local area network to support telephone networking also.

 The invention can be used in a small office or small business environment, which has a central location that comprises a telephone exchange and a digital network concentration unit (such as a hub, a switch or a router),
10 connected to multiple remote work stations via LAN wiring.

BRIEF DESCRIPTION OF THE DRAWINGS

 In order to understand the invention and to see how it may be carried out in practice, a preferred embodiment will now be described, by way of non-limiting example only, with reference to the accompanying drawings, in which:

15 **Figs. 1a and 1b** show respectively a common prior art telephone and Local Area Network configuration as used within a small office or a small business;

Fig. 2 shows a prior art telephone and local area networks using the telephone-wiring infrastructure;

20 **Fig. 3** shows a combined telephone and data communication network according to the present invention;

Fig. 4 shows schematically a data communications network having multiple phantom channels according to the present invention all sharing a common return;

25 **Fig. 5a** shows schematically a computer modified according to the invention for direct coupling to a telephone set;

Fig. 5b shows schematically a telephone set modified according to the invention for direct coupling to a computer;

Fig. 6 shows modified wall outlet that adds a phantom channel telephone service to an existing data communication system according to the present invention; and

Figs. 7a to 7d show different views of an attachable wall plug connector that adds a phantom channel telephone service to an existing data communication system according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

In the following description it is to be noted that the drawings and descriptions are conceptual only. In actual practice, a single component can implement one or more functions; alternatively, each function can be implemented by a plurality of components and circuits. In the drawings and descriptions, identical reference numerals are use to indicate those components that are common to different embodiments or configurations.

Fig. 3 illustrates a preferred embodiment of the present invention. The network **30** is a part of an IEEE802.3 local area network, using 10BaseT interfaces. A hub **16**, defining a central location, is connected to a typical computer **18a** via a cable that includes two wire pairs **17a1** and **17a2**. Each pair is operative to carry data in one direction only, one pair, say **17a1**, carrying data from the hub **16** to the computer **18a**, while the other pair, **17a2**, carries data in the other direction. Fig. 3 also shows a telephone set **13a**, associated with computer **18a** and preferably near it, and a telephone private automatic branch exchange (PABX) **11**, which is preferably also at the central location. The term hub is used herein to represent any digital network concentrating unit and may equally refer to a switching hub, a router, a server computer or to any digital device having multiple data ports; any of these being also referred to herein as a central digital device. Similarly, PABX is used herein to represent any type of central telephone switching unit and will also be referred to as a central telephone device.

According to the invention, a signal transformer is inserted at each end of each wire pair, whereby, for example, transformer **31a1** is inserted at the end of wire pair **17a1** that is near hub **16** and transformer **31b1** is inserted at the end of wire pair **17a1** that is near computer **18a**. Similarly, transformers **31a2** and **31b2** are inserted at the ends of wire pair **17a2** that are near hub **16** and computer **18a**, respectively. The signal transformers bearing the prefix **31** are designed so that the signal attenuation via these transformers is negligible. Hence, the performance of the data communication network is fully retained, and the hub **16** continues to communicate fully with the computer **18a** in the usual manner. Such transformers are known in the art and are often used in LANs, in order to meet isolation and common-mode rejection requirements. Commonly, such signal transformers are equipped with a primary winding and a secondary winding both being untapped coils. In the invention, each signal transformer bearing the prefix **31**, say **31a2** has a primary winding **35**, whose ends are connected to the respective wires of the cable, and a secondary winding **36**, whose ends are connected to the respective system component (hub **16** or computer **18a**).

However, unlike the conventional configuration for signal transformers, according to the present invention each primary winding **35** has a center-tap shown as **37a1** and **37a2**, for the two signal transformers **31a1** and **31a2**, respectively. PABX **11** is connected, via two respective wires **38a**, to the center-taps **37a1** and **37a2** of transformers **31a1** and **31a2**. Similarly, the telephone set **13a** is connected, via two respective wires **38b**, to the center-taps **37b1** and **37b2** of transformers **31b1** and **31b2**, respectively. In this configuration, the telephony signals are carried in a 'phantom' way together with the data communication signals, without any interference between the two. In practice, the hub side transformers **31a1** and **31a2** may be integrated to form a module **32a**, while the computer side transformers **31b1** and **31b2** may be integrated to form a module **32b**. While the network **30** has so far been

described as supporting a single computer and a single telephone, additional work cells, each comprising a telephone and a computer can be supported, whereby each computer is connected with hub **16** through a corresponding two wire pairs cable, by inserting an additional set of modules **32a** and **32b** in each such cable.

While the invention has been described specifically for 10BaseT (10Mb/s) interfaces, the invention can be equally applied to 100BaseTX (100Mb/s) interfaces. Furthermore, the invention can be equally applied in any wired networking system using at least two wire pairs. Transformers can be used in all wired communication systems whose signals do not include direct current (DC) components. In systems that use four or more pairs of wires, such as those based on the evolving 1000BaseTX Ethernet standard, each two pairs can be used to form a single phantom channel. Thus, four pairs can form two phantom channels, each carrying one POTS circuit, by terminating each pair with a transformer as described above. Alternatively and preferably, as shown in Fig. 4, three pairs **17a1**, **17a2** and **17a3** can each form a phantom channel with the fourth pair **17a4**, which serves as the common return path. In this case, each telephone circuit **13a**, **13b** and **13c** has one of its two wires connected to the center-tap **37b1**, **37b2** and **37b3** of the respective transformer **31b1**, **31b2** and **31b3** at the corresponding end of the respective pair and the other wire – to the center-tap **37b4** of the transformer **31b4** at the corresponding end of the common pair. More generally, with N pairs of conductors, each pair serving as a data channel, it is possible to similarly provide N-1 phantom channels for telephone service.

In the configuration shown in Fig. 3 the modules **32a** and **32b** are stand-alone modules, mechanically separate from other components in the network. However, also other configurations are possible. For example, the hub side module **32a** can be integrated, fully or in part, within the hub **16**. In such a case, the hub's existing data connection-unit (such as a distribution frame – for

connecting thereto all line pairs) is preferably substituted by one that includes module **32a**; in addition, a telephone connector is provided, for connecting all telephone lines (whose other ends are connected to their respective center taps in module **32a**) to the PABX. Alternatively, module **32a** can be similarly
5 integrated within PABX **11**, whereby an appropriate connection with the hub is provided.

Fig. 5a shows schematically an arrangement where the computer side module **32b** is integrated, fully or in part, within the computer **18a**. Thus, the secondary windings **36** of the transformers **31a1** and **31a2** are connected to receiver and transmitter circuitry **39a** and **39b** within the computer **18a**. The
10 ends of the primary windings **35** of the transformers **31a1** and **31a2** are connected to a standard socket outlet **40** for connecting to the network. The center-taps **37a1** and **37a2** are connected to a standard telephone outlet **41**, enabling connection thereto of a telephone set such as designated **13a** in Fig. 3.

Fig. 5b shows schematically the complementary arrangement where the module **32b** is integrated the telephone set **13a**. Thus, the secondary windings **36** of the transformers **31a1** and **31a2** are connected to a standard outlet **42** for connecting thereto a computer such as designated **18a** in Fig. 3. The ends of the primary windings **35** of the transformers **31a1** and **31a2** are connected to a
15 standard socket outlet **43** for connecting to the network. The center-taps **37a1** and **37a2** are connected to telephone circuitry **44**, within the telephone set **13a**.

Alternatively, the computer side module **32b** can be integrated within a wall connector allowing direct or indirect connection to an existing wall socket outlet. Thus, such a wall connector can be constituted by a substitute wall
20 socket having integrated therein a pair of signal transformers and two female outlets for connecting a computer and telephone thereto, respectively. Alternatively, the wall connector can be constituted by a plug connector having integrated therein a pair of signal transformers and two female outlets for connecting a computer and telephone thereto, respectively. Such a plug

connector allows a computer and telephone to be connected to an existing wall socket outlet without requiring any modification thereto.

Fig. 6 shows the faceplate of a modified socket outlet **45** according to the invention. Two conductor pairs are connected to the outlet at the rear (not shown in the Figure), connected to the primary windings of two signals
5 transformers housed in it (not shown in the Figure). The secondary windings of the transformers are connected to RJ-45 data connector **46**, while the center taps are connected to the RJ-11 telephony connector **47**. Such an outlet is physically similar in size, shape, and overall appearance to a standard outlet, so
10 that such an outlet can be substituted for a standard outlet in the building wall. No changes are required in the overall LAN line layout or configuration. Such an outlet can easily substitute an existing standard data outlet to thus additionally provide telephony support. Thus a conventional outlet has a single female connector having two pairs of wiper contacts connected to the
15 respective twisted-wire pairs for data transmission and reception. A computer is plugged into such a conventional outlet via a single male connector (plug) having four pins: two for handling data transmission and two for handling data reception. On inserting the plug into the socket outlets, the pins brush against the wiper contacts in the socket outlet, thus establishing electrical connection
20 between the two.

The invention allows for the conventional outlet to be replaced by a modified outlet having therein a pair of signal transformers, the ends of whose respective primary windings are adapted to be connected to the ends of a respective conductor pair in the network. The secondary winding of each signal
25 transformer is connected internally to a respective pair of wiper contacts of a first female connector. Thus, the ends of both secondary windings are connected to first female connector by means of four wiper contacts in total. The respective center-taps of each of the two primary windings are connected to a pair of wiper contacts in a second female connector proximate the first

female connector. Thus, a computer can be connected, via four pins of a suitable jack plug, to the first female connector, while a telephone can be connected, via two pins of a suitable jack plug to the second female connector. The two wire pairs **17a1** and **17a2** are routed and connected to such an outlet, which will now comprise two faceplate connectors – a data connector (e.g. RJ-45 for 10BaseT) and a telephone connector (e.g. RJ-11).

Such an implementation requires that the socket outlets in an existing data network be replaced by a modified outlet according to the invention. Figs. 7a to 7d show various views of a plug assembly **50** according to the invention for operation in 10BaseT or 100BaseTX environment that allows the invention to be implemented without requiring any modification to the data network or to the existing socket outlet. In use, the plug assembly **50** is plugged into a standard socket outlet and is retained therein by means of a latch **51**. The plug assembly **50** contains the module **32b** connected to separate data- and telephony socket outlets **52** and **53** in a similar manner to the modified socket outlet **45** described above with reference to Fig. 6. A standard RJ45 jack plug **54** is connected to the module **32b** for mating with the wall outlet when plugged into its socket. The jack plug **54** thus includes two pairs of pins each connected to the primary winding of a respective signal transformer within the module **32b**. The secondary windings of the two signal transformers are connected to respective wiper contacts in the data-telephony socket outlet **52**. The respective center-taps of each of the primary windings are connected to a pair of wiper contacts in the telephony socket outlet **53** proximate the data-telephony socket outlet **52**. Cables from the computer and the telephone set terminate in standard jack plugs that are plugged into the respective data- and telephony socket outlets **52** and **53** within the plug assembly **50**. Thus, the plug assembly **50** obviates the need for any changes to be made to the existing infrastructure.

As mentioned above, 10BaseT and 100BaseTX interfaces, as well as other data communication interfaces, often include signal transformers in the line connection circuitry, in order to meet isolation and common-mode rejection requirements. In such cases, additional transformers, though possible, are not required and the method of the present invention can be implemented by adding center-tap connections to the respective windings of the existing transformers and using them to form a phantom channel, to serve for telephone connection in the manner described above. Alternatively, the existing transformers can be substituted by ones with center-taps as specified above.

It is noted that, while a phantom channel has been known in the art, its use in the system and method disclosed herein is novel, because:

(a) Local area networks (LANs) in general, and Ethernet networks in particular, currently do not employ phantom channels, nor is any configuration employing such channels specified in the IEEE802.3 standards; the concept is known in the realm of telephony only, which is very different from that of data communication LANs.

(b) Using a phantom channel itself to carry POTS service is not known in the art; rather, phantom channels are used only to carry power to remote units and/or management- or control signals to support the main service that is provided by the two conductor pairs.

While the invention is described above relating to hub units, it is clear that any other multi-port data communication device can be used, such as switch, router or gateway.

The present invention also embraces a method for upgrading an existing local area network (LAN) installation that includes a two-conductor pair cable between two digital devices, to also and simultaneously convey signals between two telephone devices, the method comprising:

(a) inserting a first pair of signal transformers having center-tapped primary windings at a first end of the cable, with respective ends of

the primary windings connected to respective conductors of the cable; and

- (b) inserting a second pair of signal transformers having center-tapped primary windings at a second end of the cable, with respective ends of the primary windings connected to respective conductors of the cable;

thereby allowing respective secondary windings of each signal transformer to be connected to the digital devices and allowing the respective center-taps of the signal transformers to be connected to telephone equipment.

If the LAN already includes signal transformers that do not have center-taps, they are, in step (a) above, replaced by the specified transformers or, alternatively, a center-tap is added to each primary winding.

While the invention has been described with respect to a limited number of embodiments, it will be appreciated that many variations, modifications and other applications of the invention may be made.